AN INEXPENSIVE AUTOMATIC WATER SAMPLER
Specifications and Plans

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CONTENTS

Illustrations

AN INEXPENSIVE AUTOMATIC WATER SAMPLER
Specifications and Plans

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INTRODUCTION

The primary water-quality problem facing agriculture is to identify potential sources of water pollution, such as sediment, pesticides, and nutrients contained in fertilizer and manure, which leave farms in runoff water. Some of these substances may change rapidly with time or with variations in temperature, and it is therefore necessary to collect, refrigerate, and analyze water samples on a timely basis. Since runoff events cannot be accurately predicted, it is necessary to have automatic sampling equipment.

Most existing automatic samplers are too large or too expensive for economical use in refrigerated sampling programs. The sampler described herein was developed to satisfy the need for a relatively small, inexpensive, versatile, and easily maintained unit that can automatically take samples and deliver them to existing refrigeration units. Applicable refrigeration units are not discussed in this paper.

Two samplers of the type described herein were tested during 13 runoff events, each lasting 1 to 3 days, at the Agricultural Research Service's Watershed Research Center, Chickasha, Okla., and only minor problems arose. Samples collected with this sampler were well correlated with samples collected by the Federal Inter-Agency Sedimentation Project[2] PS–66 samplers that were also installed at the sampling sites.

The cost of the basic sampler, excluding labor, is approximately $225. Fabrication, assembly, and testing require approximately 50 man-hours. Installation time varies with complexity of installation type.

SAMPLER FUNCTIONS

The complete sampler (fig. 1) consists of two assemblies: an upper unit consisting of a volumetric trap and control unit, and a lower unit consisting of a nozzle turntable and sample bottle holder.

The sampler is automatically activated by a water-level sensor (WLS).[3] An event marker (EV)[4] may be used to record sample times if desired. When the water-level sensor is closed, power is applied to the control unit.

The control unit, containing electronic clock circuits, consists of resistor/capacitor (R/C) networks, unijunction transistors, and relays that control the mechanical functions of the sampler. A master clock in the control card circuitry allows a sampling frequency of 0.25, 0.50, 1, 2, and 6 hours. A 5-minute sampling frequency can be added with the addition of resistor R29 (fig. 2). The control card also energizes a mechanical operation card that, together with the clock, controls the sampling cycle. Sample pump relay K5 is
by the control card and is deacti
onds later by a solid

An optional mode
sible whereby the

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[2] A cooperative Federal program dedicated to the development of sediment collection and analysis apparatus.

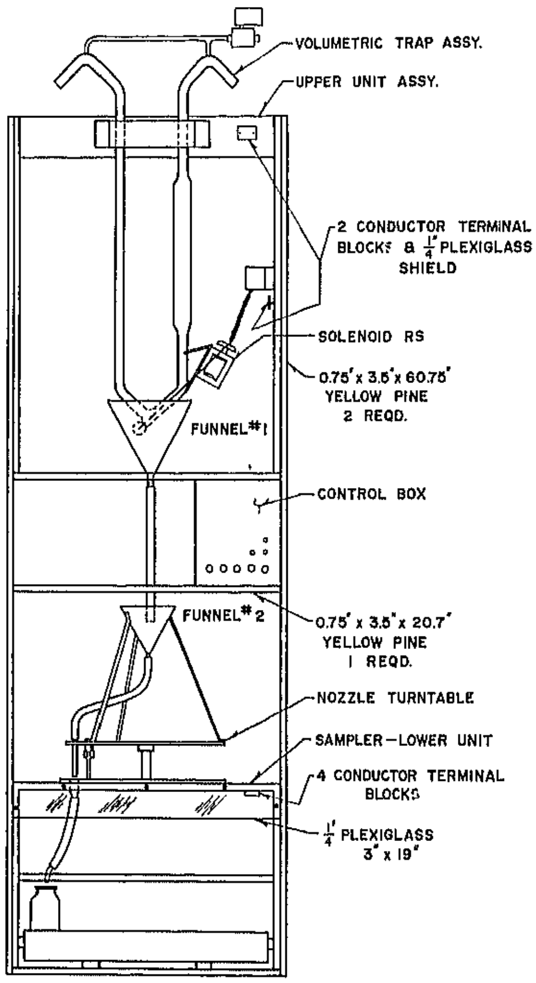


FIGURE 1.—Automatic water sampler assembly.

supplanted by spare energizing contacts in another sampler (piggyback model). This mode is convenient for simultaneous operation of two samplers with one pumping system. In this mode, relay K9 is utilized to energize solenoid valve RSV and solenoid RS. Relay K9 is energized by the substituted diverter control circuit, and the 1-pint volumetric trap opens simultaneously with the trap of the substituted circuitry.

The operational card controls the advancement of the sample nozzle through motor M1. Solenoid RS, solenoid valve RSV, and the event marker, EV, are activiated by the operational card after each sample is pumped. Microswitch S3 automatically stops the sampler after 24 samples have been collected.

The power requirement is 120 volts a.c. delivered to the pump (M2) and control unit. The self-priming pump delivers a 3/4-inch stream of water against a discharge head of up to 20 feet, and the pump has operated reliably at a suction head of 6 feet. Twenty-five seconds after the pump shuts off, the solenoid valve RSV and solenoid RS are activated simultaneously for 20 seconds, and the sample is discharged from the volumetric sample trap to the 1-pint, square, sample bottle. To prevent contamination, the sample delivery nozzle remains over the filled sample bottle until the next sample cycle is initiated.

An alternate pumping mode is possible, whereby samples are pumped from a substitute sediment sampler. This substitute pumping system should be from the Inter-Agency Sedimentation Project models PS-66 and PS-67 or their equivalents. In this mode, discharge from the substitute sampler trap is connected as directly as possible to the inlet of the other volumetric sample trap. The outlet of the latter must be routed to the substitute pump-priming reservoir, if applicable. In all modes of operation, the tubing should be as short as possible to prevent siphoning.

FABRICATION AND ASSEMBLY

The electronic control unit consists of three printed circuit boards (figs. 3–5). Negatives can be made directly from these figures for use in photoetching, or the resist method can be used by simply transferring the foil pattern to copper-clad board. Component placement on the circuit boards is shown in figures 6–8. The schematic, figure 2, gives the complete wiring diagram and connections. The location of microswitches S2 and S3 and the turntable drive motor (M1) are shown in figure 9. The various components and assemblies of the control unit are mounted on the control unit front panel as shown in figure 10.

The main frames of the upper and lower assemblies of this sampler can be fabricated of any suitable material. Wood can be used, but it should be painted with an epoxy paint or spar varnish to retard deterioration by moisture.

The nozzle turntable (fig. 11) and sample drop tube and distribution boards (figs. 12 and 13) are constructed from durable, lightweight

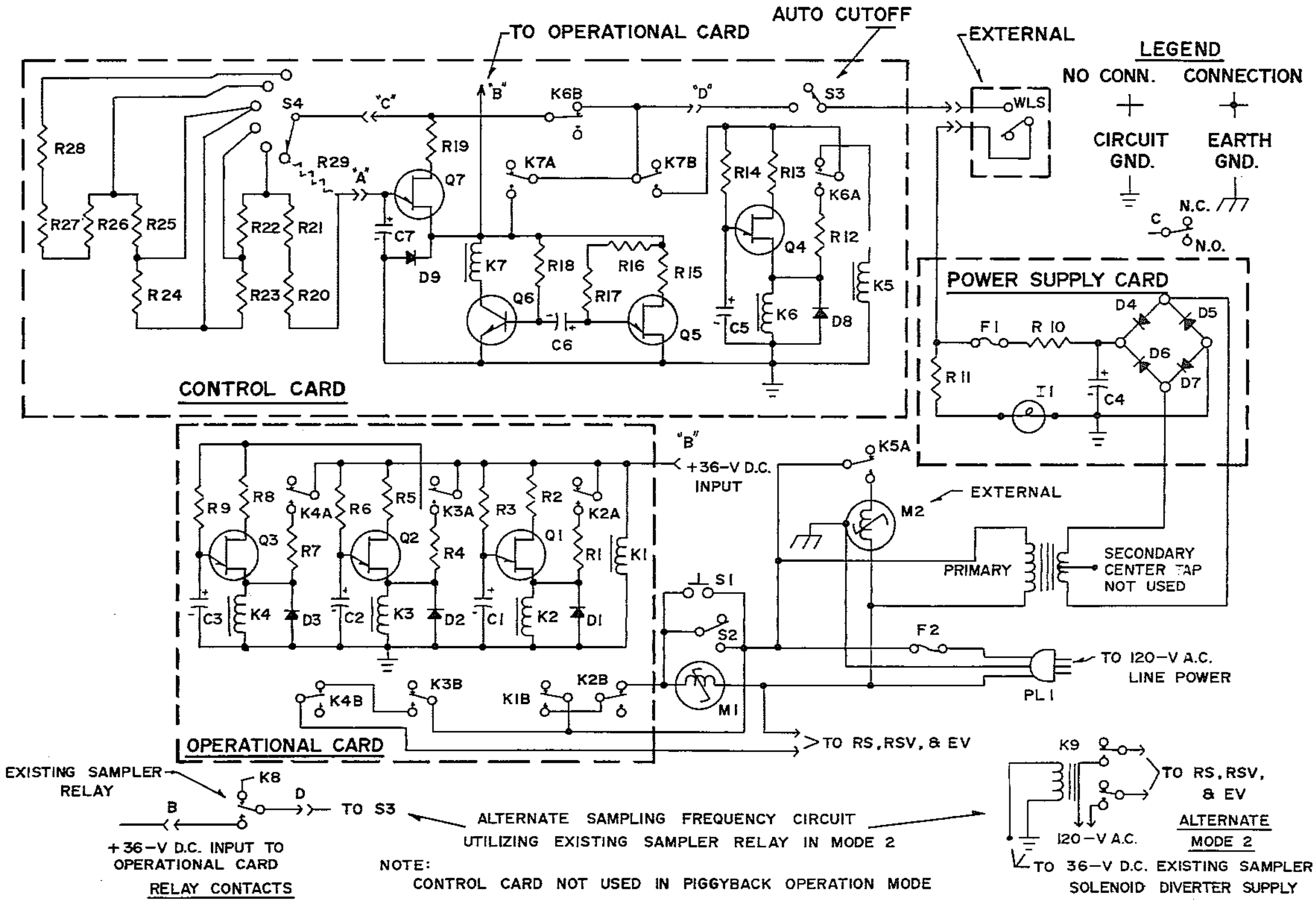


FIGURE 2.—Schematic wiring diagram.

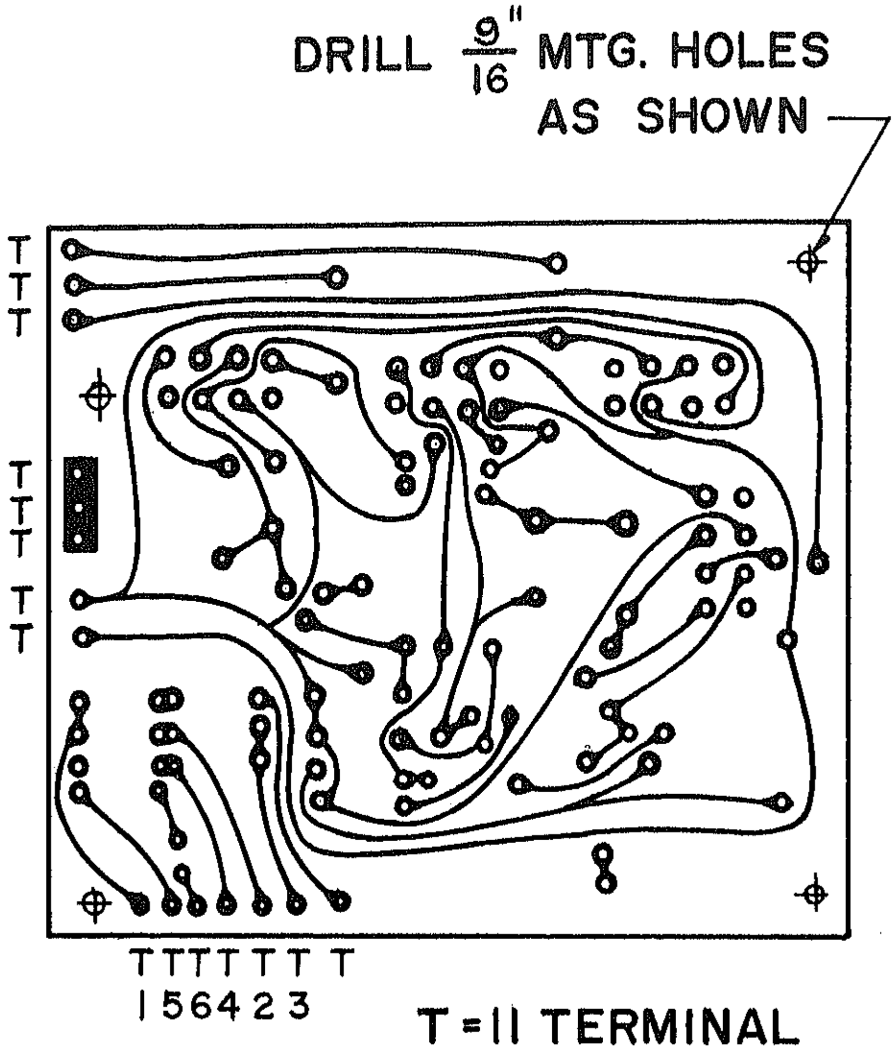


FIGURE 3.—Operational card, foil side, actual size.

¼-inch plexiglass. The polystyrene sample delivery nozzle and copper fittings (figs. 11 and 14) are bonded to the board with a high-quality, clear, epoxy glue. If properly bonded, these components will withstand considerable abuse.

The volumetric trap (fig. 15) consists of copper tubing and fittings. The joints are brazed with Sil-Foss, a silver and copper alloy, which has a higher tensile strength than soft solder. Location and mechanical details of all sampler components on the main frames are shown in figures 16–27. Solenoid RS and the sample valve are shown mounted to the volumetric trap in figure 15.

SETUP AND ADJUSTMENTS

After assembly, microswitches S2 and S3 may require minor adjustment. Switch S3 should be adjusted so that normally open contacts are closed when the actuator roller rests on the flat undersurface of the nozzle turntable. The closed contacts of S3 should then open when the actuator roller drops into the automatic cutoff depression on the bottom of the turntable. Switch S2 should be adjusted in the same manner as S3 to insure that it operates properly in all 26 positions. The nozzle turntable is advanced by a 2-second pulse from the operational card, which actuates switch S2 and the table drive. Nor-

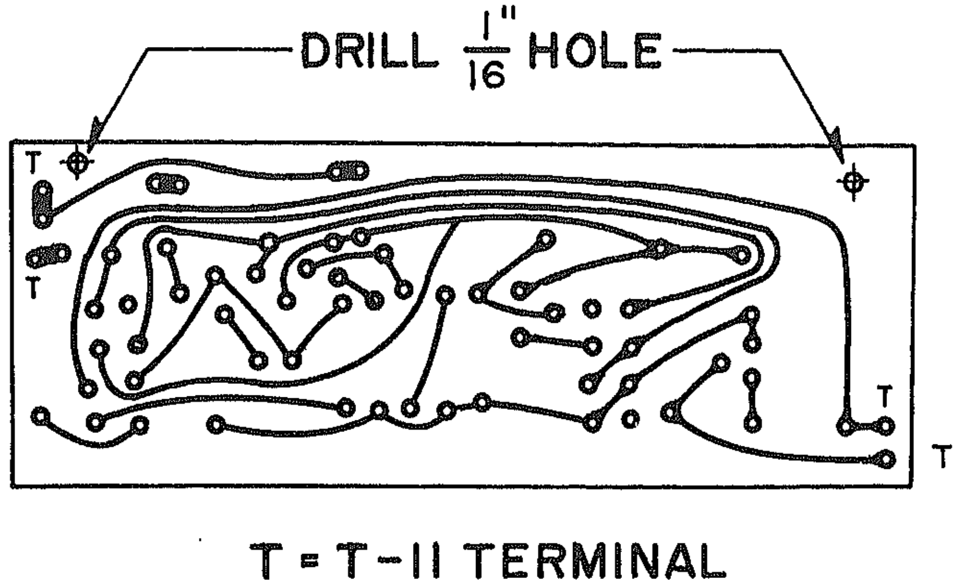


FIGURE 4.—Control card, foil side, actual size.

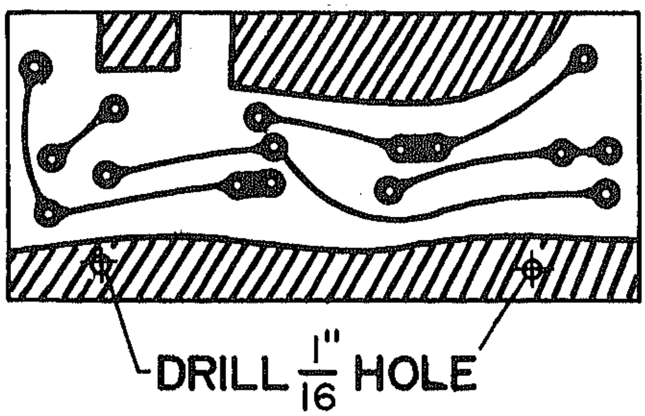


FIGURE 5.—Power supply card, foil side, actual size.

mally, the turntable is advanced automatically. Do not rotate the turntable by hand! However, the table can be advanced manually, one sampling position at a time, by depressing the reset switch (S1) for 1 second. This applies a 120-volt a.c. pulse to advance the drive motor.

The volumetric trap-sample valve should be fully closed when solenoid RS is in the deenergized state. This will eliminate possible leakage into the sample bottle when water is being pumped through the system. Proper operation of the valve is accomplished by adjusting the valve guide rods to the solenoid head. No other sampler adjustments are required, but tests should be made through several complete cycles.

INSTALLATION

The pump should not be installed more than 6 feet above the expected low water level or pumping will be affected. If high water levels are anticipated, the pump must be mounted in an airtight hood that is securely anchored (fig. 28).

The sampler can be installed as an integral unit for sediment sampling. However, water-quality sampling requires separate installation of the sample containers under refrigeration. Such installation requires that the upper unit be located with its bottom at least 8 inches higher than funnel 2 in the lower unit (fig. 1). The lower unit is installed in a refrigerated compartment or refrigerator.

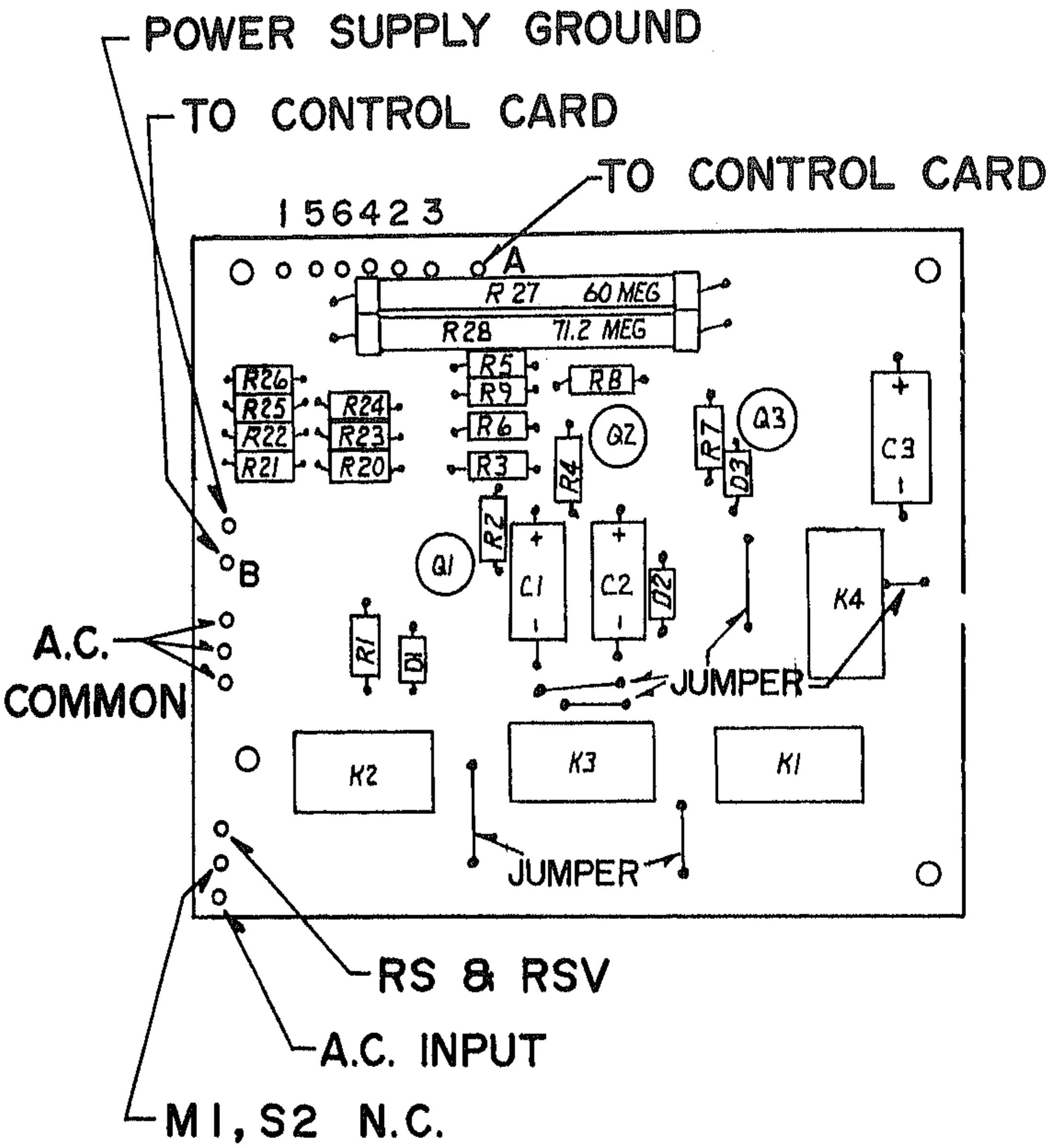


FIGURE 6.—Operational card, component placement.

A reliable electrical service ground should be provided between all equipment. The pump motor must be grounded separately through the three-wire power cable, and the entire installation must be completed before the power connection is made.

Small, self-priming pumps are usually not very reliable. They often fail to prime fully and will not discharge a full stream under a moderate head. The pump used in this sampler was chosen for its reliability in these respects.

Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

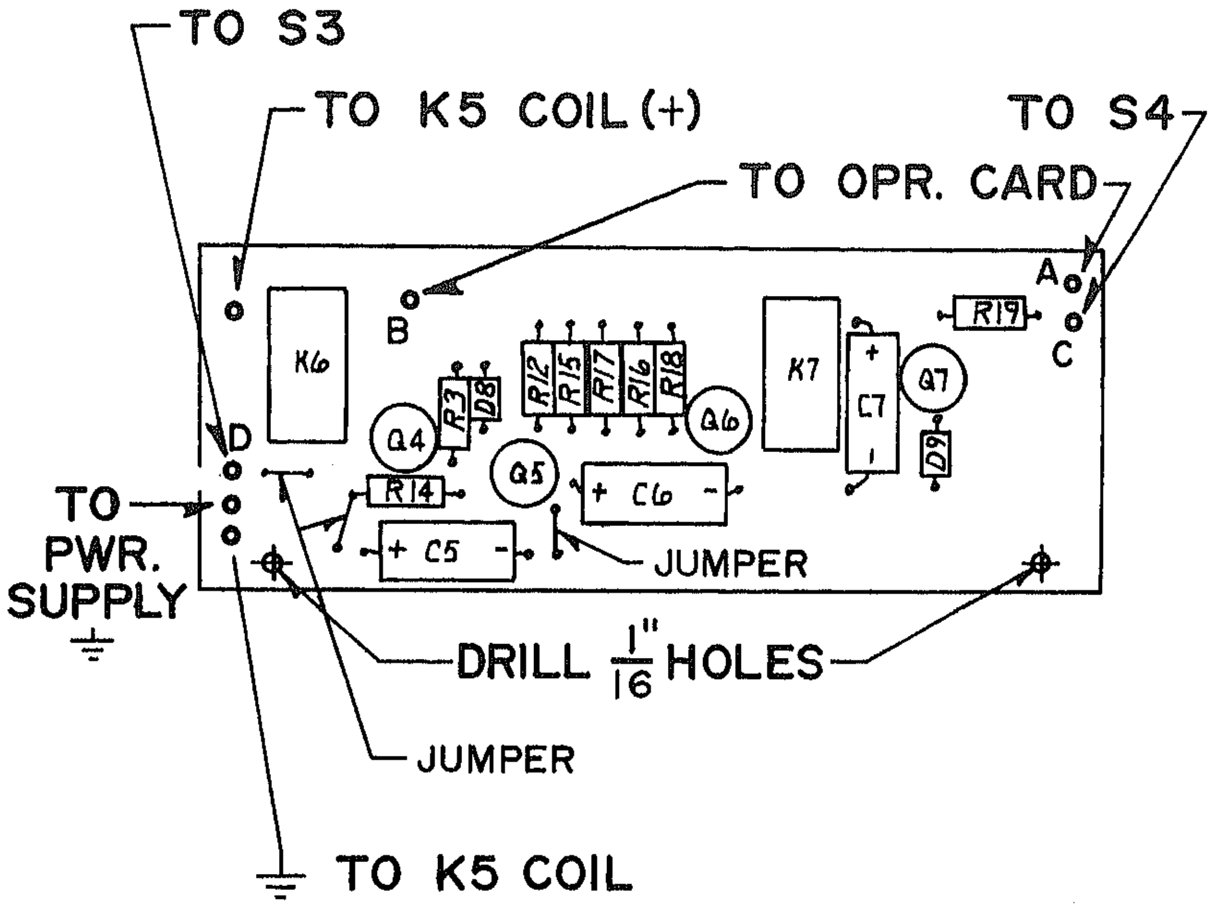


FIGURE 7.—Control card, component placement.

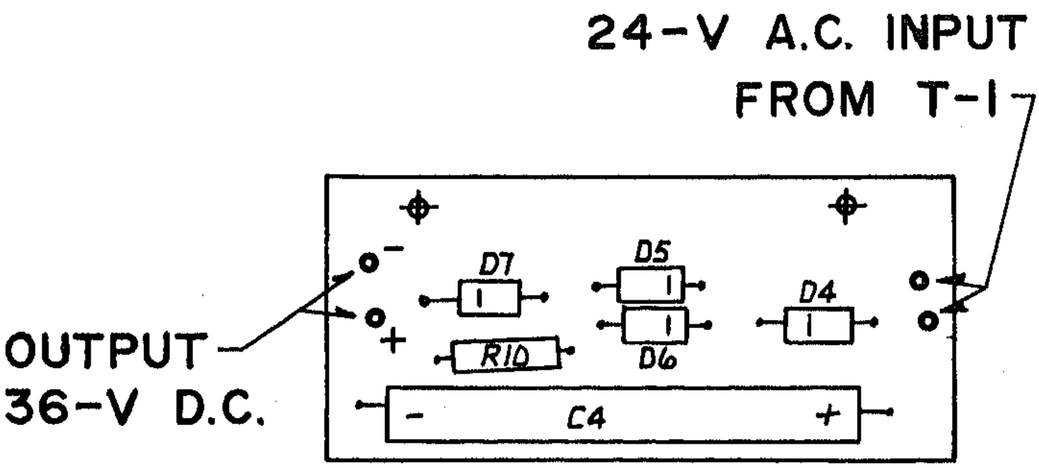


FIGURE 8.—Power supply card, component placement.

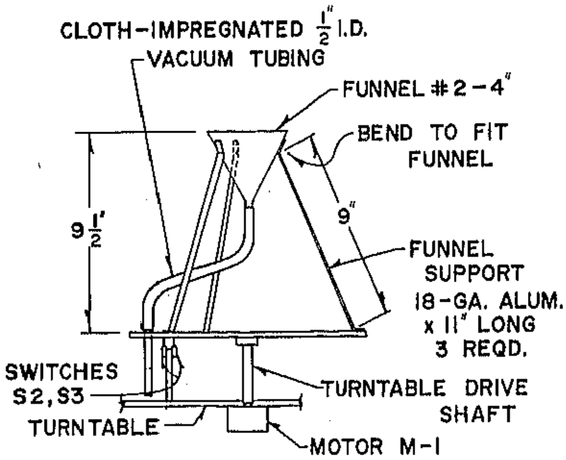


FIGURE 9.—Nozzle turntable assembly.

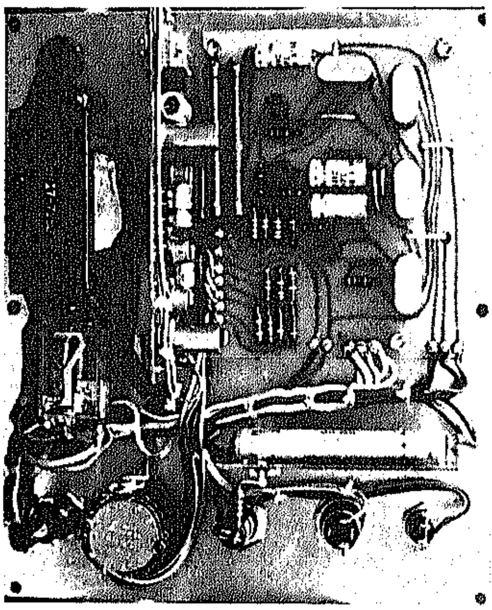


FIGURE 10.—Electronic control unit, rear view.

PARTS LIST

Capacitors (C)

All capacitors 50 working volts, Sprague CL65BG181KPE, unless otherwise speciifed.

Symbol	*Specification*
C1, C2, C3, C5, C6	180 μF
C4	150 μF, CL25BJ151VP3
C7	56 μF, Sprague CL65B560KPE

Diodes (D)

Symbol	*Specification*
D1, D2, D3, D8, D9	1N457
D4, D5, D6, D7	1N3253

Relays (K)

All relays 24 volts d.c.

Symbol	*Specification*
K1, K2, K3, K4, K6, K7	Potter and Brumfield HP11d
K5 or K9	Potter and Brumfield R10-E1-V2-V700
K8	A component of an existing sampler (mode 2)

Resistors (R)

Resistance tolerance 5 percent, 0.5 watt, unless otherwise specified.

Symbol	*Specification*
R1	330 Ω
R2	330 Ω
R3	10 kΩ
R4	330 Ω
R5	330 Ω
R6	470 kΩ
R7	330 Ω
R8	330 Ω
R9	220 kΩ
R10	15 Ω, 1 W
R11	360 Ω
R12	330 Ω
R13	330 Ω
R14	300 kΩ
R15	470 Ω
R16	680 kΩ
R17	1 kΩ
R18	2.2 kΩ
R19	330 Ω
R20	22 MΩ
R21	6.8 MΩ
R22	10 MΩ
R23	22 MΩ
R24	10 MΩ
R25	15 MΩ
R26	22 MΩ
R27	60 MΩ, 1 pct, 1 W
R28	71.2 MΩ, 1 pct, 1 W
R29	10 MΩ

Switches (S)

Symbol	*Specification*
S1	Momentary push button, white, Switchcraft DA-05-3-265
S2, S3	Robert Shaw 11SM3 with 037-0226-00 actuator
S4	6-position rotary, Grayhill 44M30-02-2-6N

Transistors (Q)

Symbol	*Specification*
Q1, Q2, Q3, Q4, Q5	2N1671A
Q6	2N2108
Q7	2N494C

Miscellaneous

Symbol	*Specification*
EV	Event marker, user option
F1	Fuse, 0.5-A, AGC
F2	Fuse, 3-A, AGC
I1	Pilot lamp and holder, 14-V d.c., Drake 1465-14VDC
M1	Synchronous motor, 115-V a.c., 0.5-r/min, clockwise rotation, Hurst model EA-H
M2	Pump and motor assembly, 110-V a.c., Western Brass Works model 3MPU-110VAC
PL1	Cord set, 3-conductor, Belden 174475
RS	Solenoid, The Westward Co., type 7014
RSV	Solenoid valve, Sporlan type A3S1, 120-V a.c.
T1	Transformer, Triad F-45x Fil
WLS	Water-level sensor, user option
.....	2 Buss fuse holders
.....	4 Cinch barrier terminal strip #2-140
.....	1 Keystone #702 phenolic case and aluminum cover
.....	1 Knob

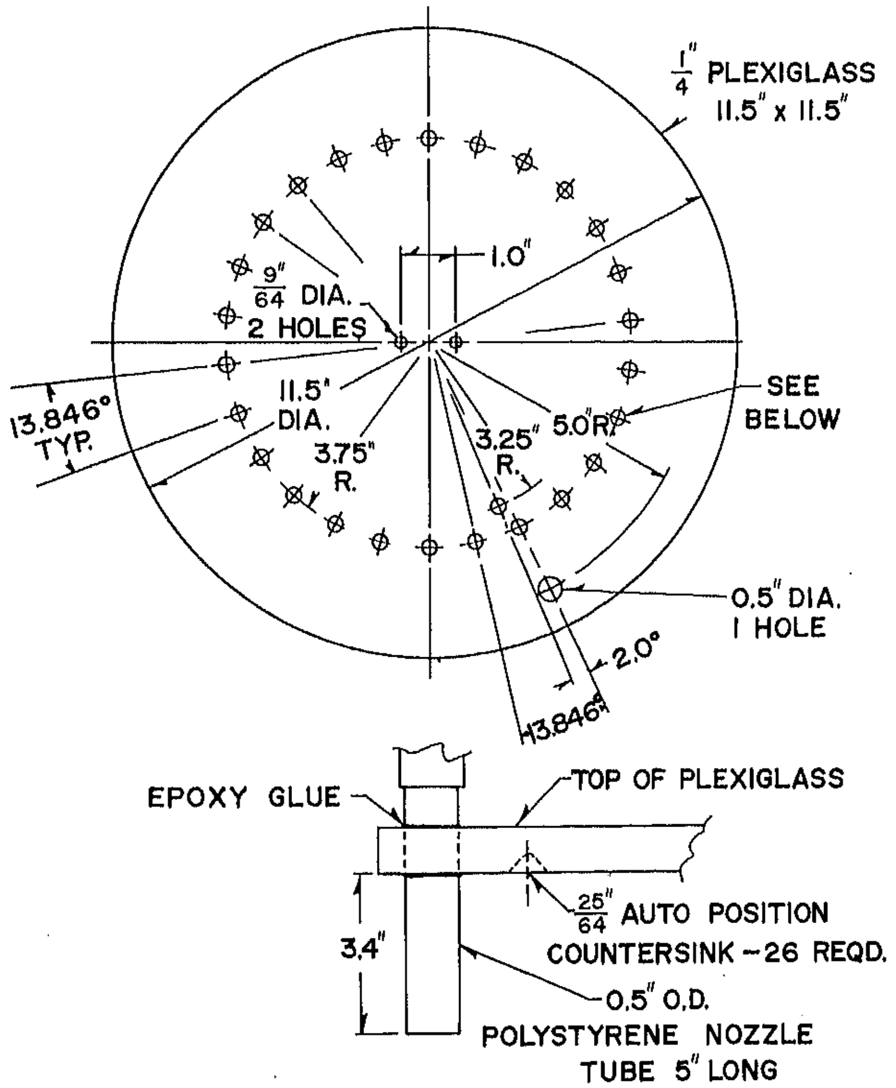


FIGURE 11.—Nozzle turntable detail.

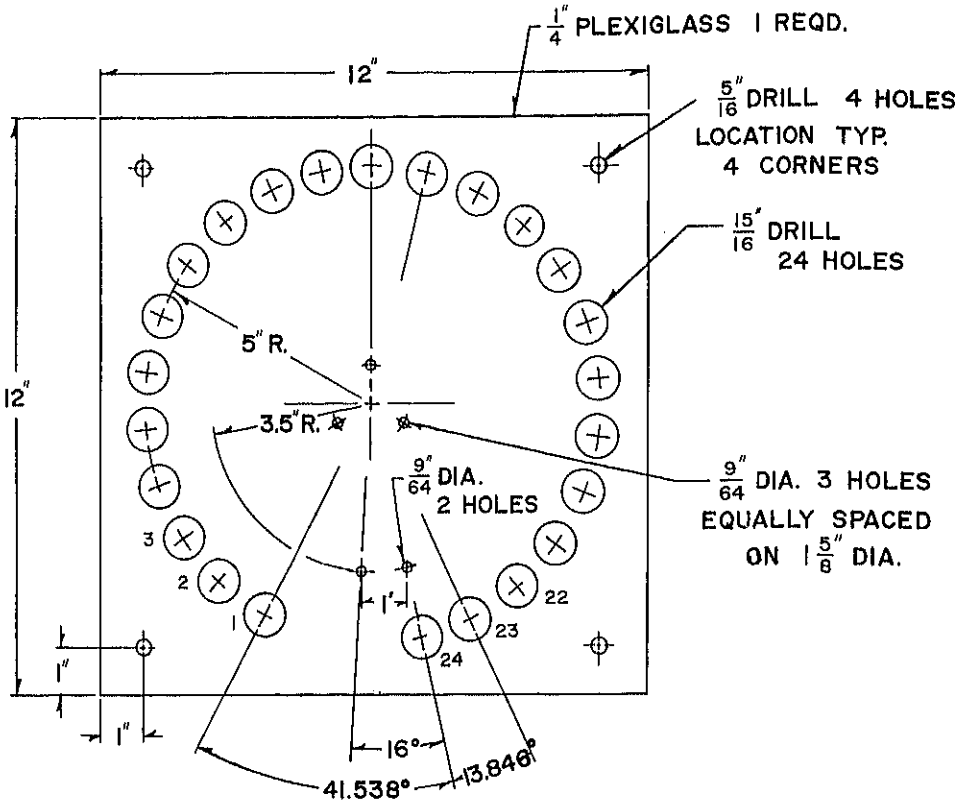


FIGURE 12.—Sample drop tube board.

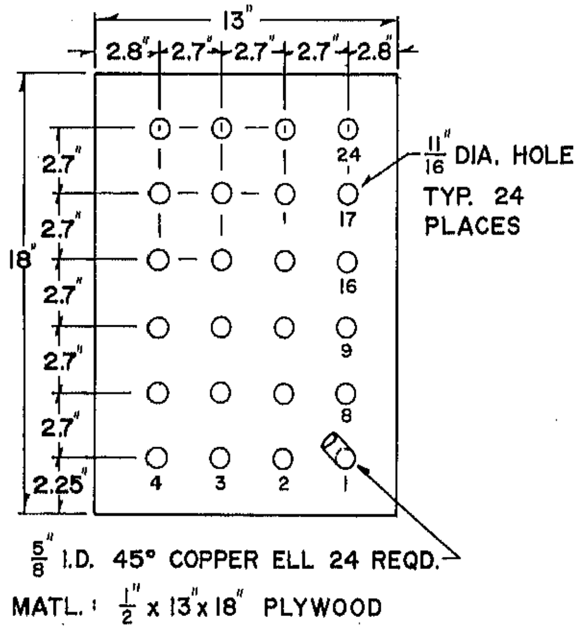


FIGURE 13.—Tubing distribution board.

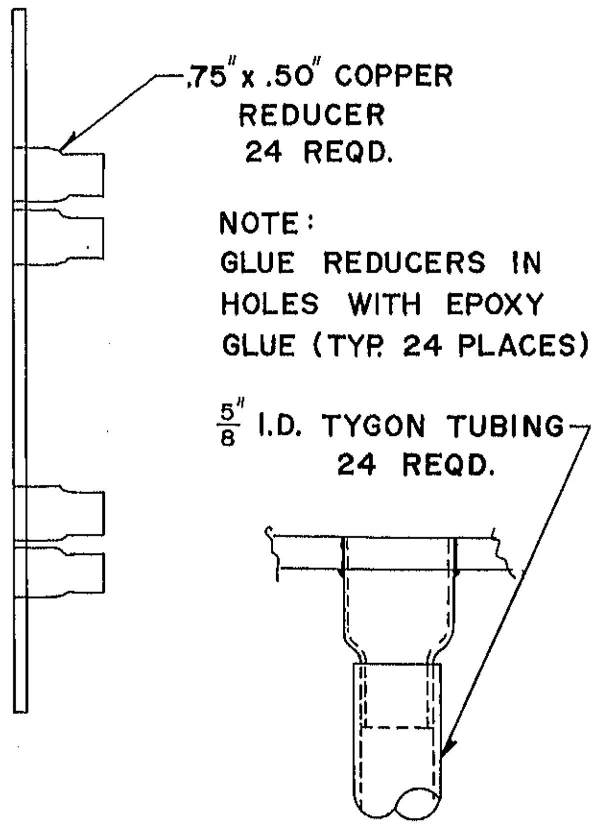
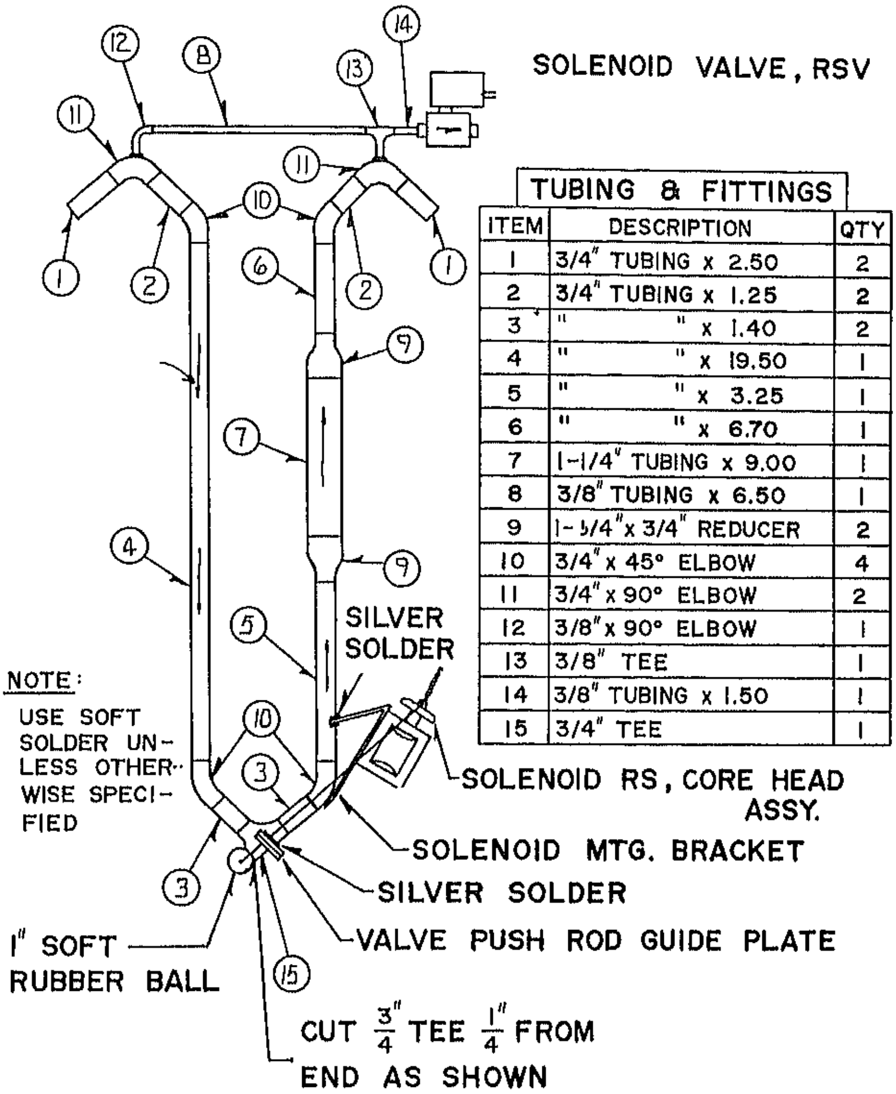


FIGURE 14.—Sample drop tube board assembly detail.



TUBING & FITTINGS

ITEM	DESCRIPTION	QTY
1	3/4" TUBING x 2.50	2
2	3/4" TUBING x 1.25	2
3	" " x 1.40	2
4	" " x 19.50	1
5	" " x 3.25	1
6	" " x 6.70	1
7	1-1/4" TUBING x 9.00	1
8	3/8" TUBING x 6.50	1
9	1-1/4" x 3/4" REDUCER	2
10	3/4" x 45° ELBOW	4
11	3/4" x 90° ELBOW	2
12	3/8" x 90° ELBOW	1
13	3/8" TEE	1
14	3/8" TUBING x 1.50	1
15	3/4" TEE	1

FIGURE 15.—Volumetric trap assembly.

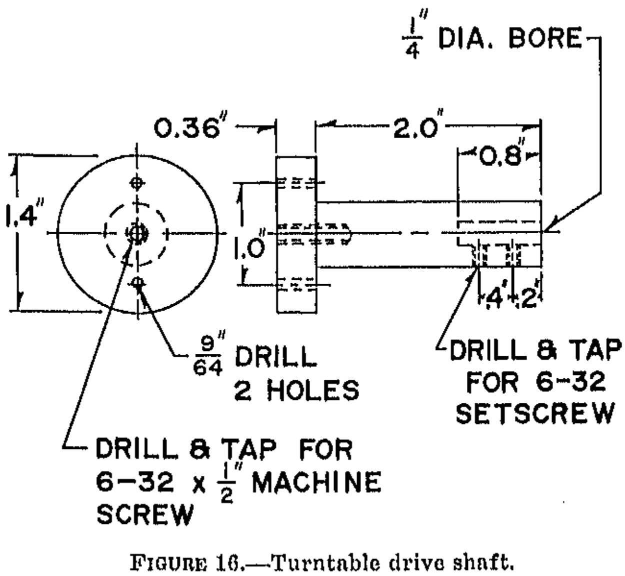


FIGURE 16.—Turntable drive shaft.

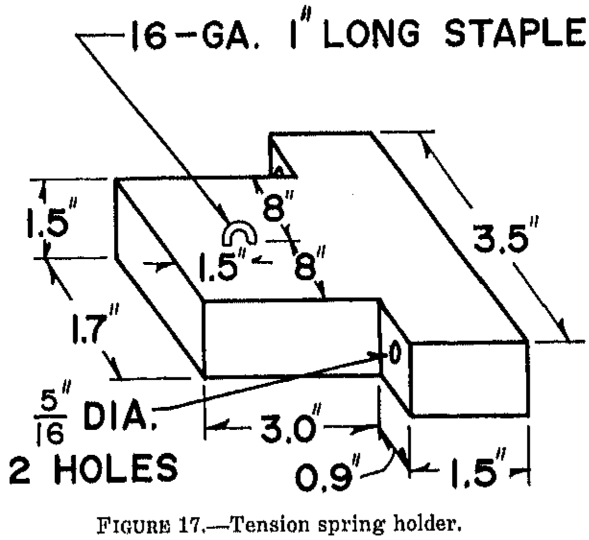


FIGURE 17.—Tension spring holder.

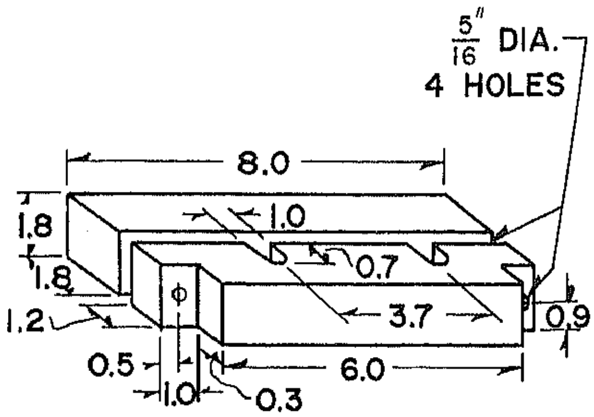


FIGURE 18.—Volumetric trap clamp.

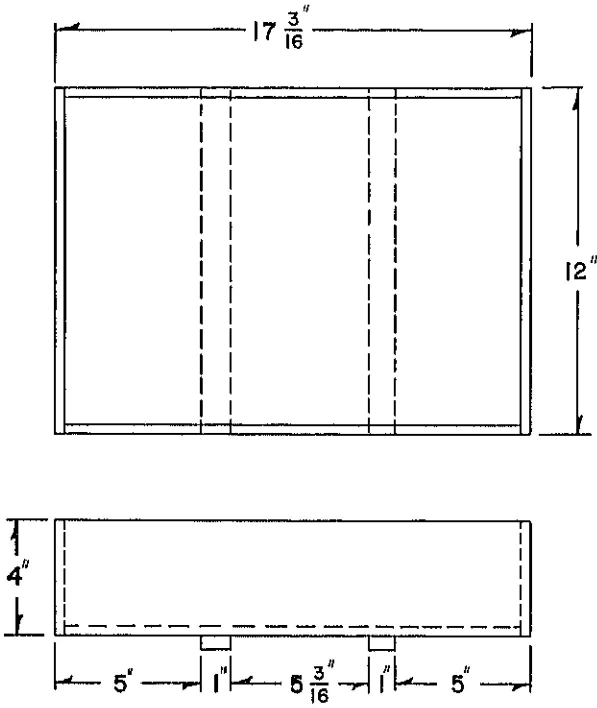


FIGURE 19.—Bottle container.

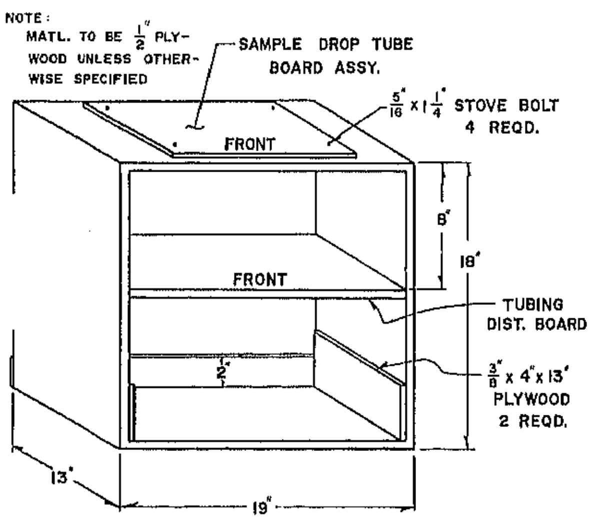


FIGURE 20.—Sampler lower unit assembly.

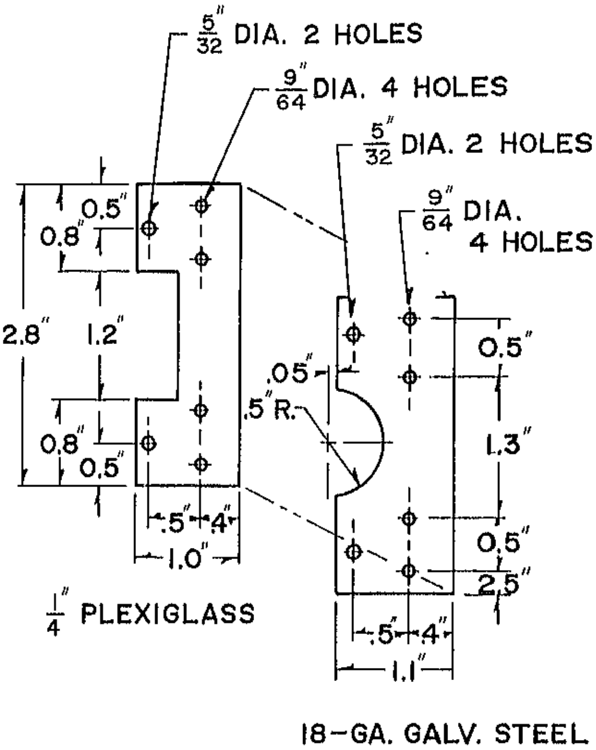


FIGURE 21.—Valve push rod guide.

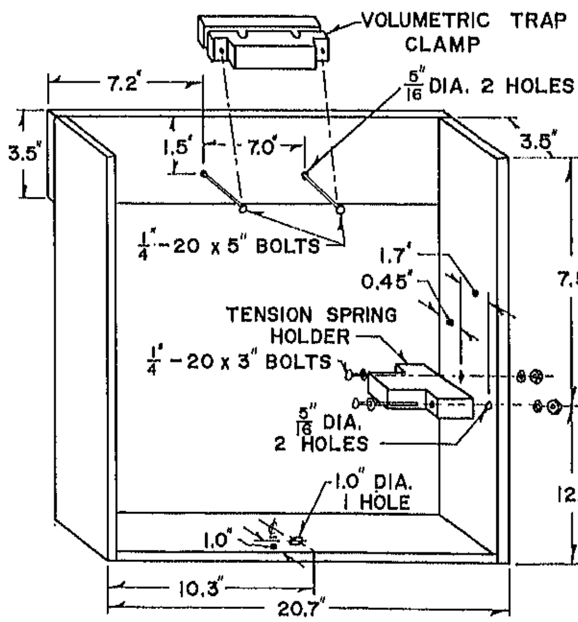


FIGURE 22.—Sampler upper unit assembly.

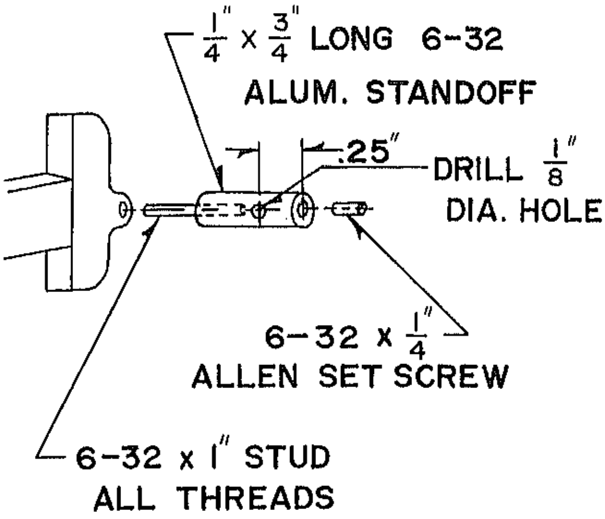


FIGURE 23.—Solenoid RS, core head assembly.

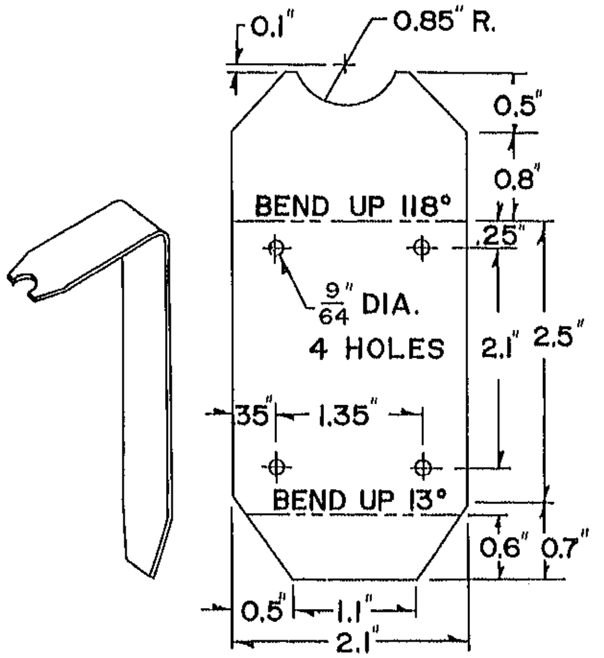


FIGURE 24.—Solenoid mounting bracket.

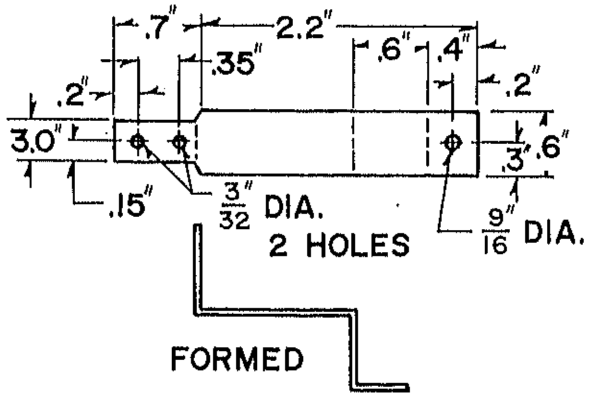


FIGURE 25.—Relay K5 mounting bracket.

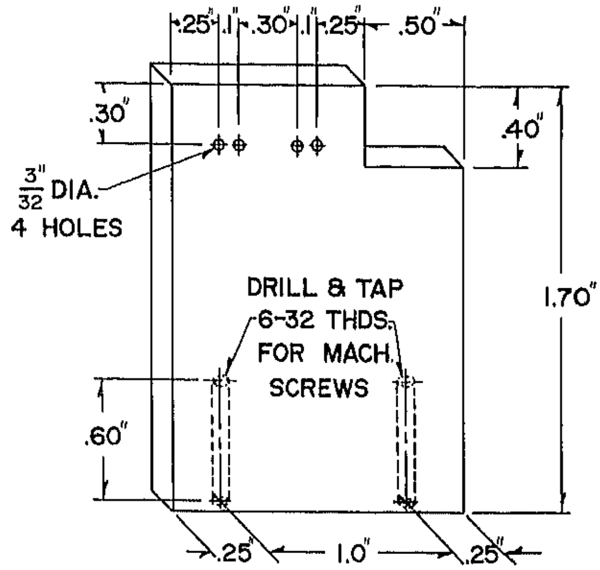


FIGURE 26.—Plexiglass mounting block for switches S2 and S3.

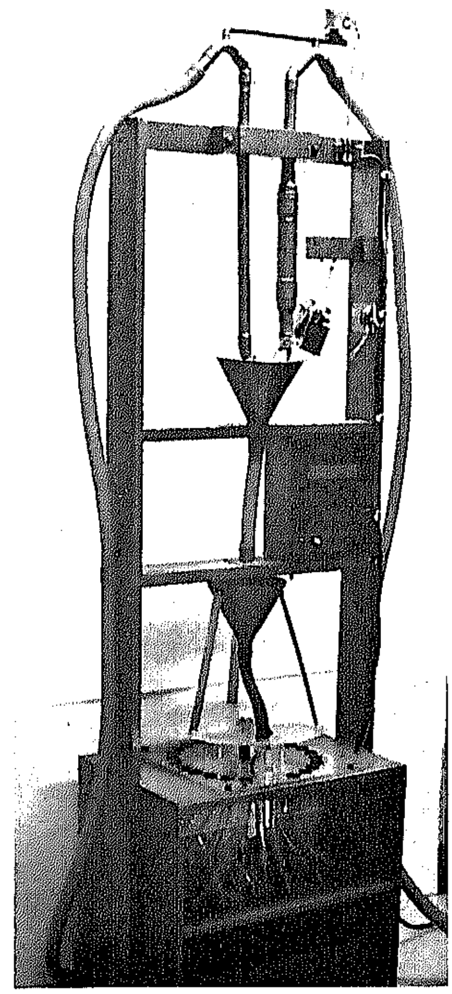


FIGURE 27.—Completed automatic water sampler.

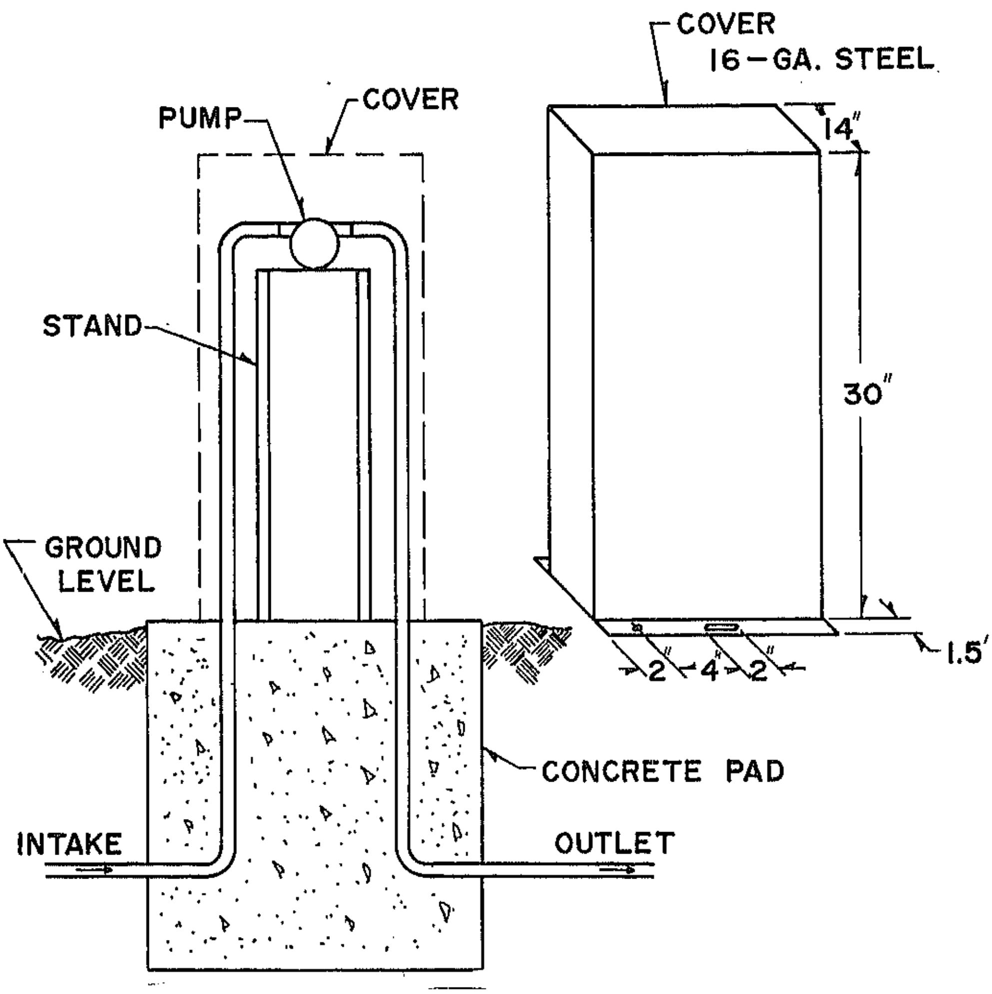


FIGURE 28.—Pump installation detail.

ACKNOWLEDGMENT

The author expresses appreciation to W. L. Curtis, air-conditioning equipment mechanic, Agricultural Research Service, for fabrication and assembly of the mechanical components of the prototype sampler.